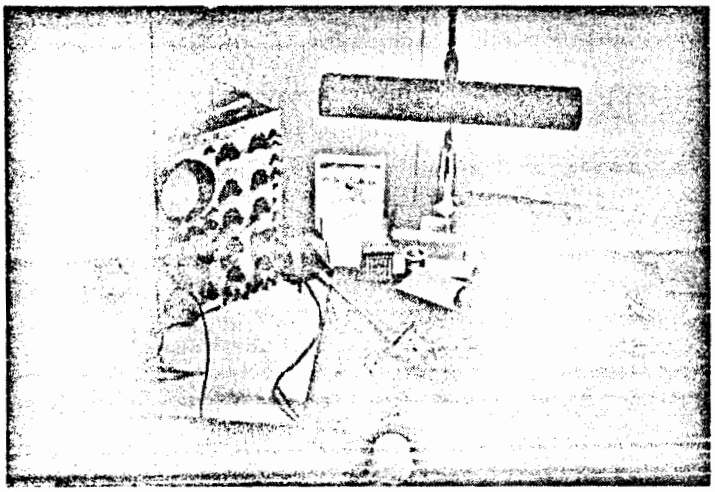
ACE R/C INC. DIGITAL COMMANDER

BY FRED M. MARKS AS PRESENTED IN AMERICAN AIRCRAFT MODELER

TROUBLESHOOTING



INTRODUCTION

This section will be devoted to providing a better understanding of the Ace Digital Commander system, and thus any digital system. It is hoped this will be achieved by presenting system integration procedures, by indicating how parts of the system might be used with other systems, and by presenting troubleshooting procedures for those who have some test equipment.

System Integration Procedures

The individual tune-up procedures have been described in detail for the transmitter; and receiver and servo neutral set-up instructions were provided. It would be wise to review those detailed procedures as the integration procedures to follow are studied.

The use of batteries and switch harness arrangement are largely left up to the builder, depending on his planned system application. The following recommendations are in order: (a) It is rather pointless to buy alkaline energizers for the receiver or transmitter packs at around 70 cents per cell when excellent 450 mah nickel-cadmium cells, which may be re-charged hundred of times, can be purchased for around $1.50 - $2.00 per cell from several sources; (b) If alkaline energizers are used, three will suffice to provide 4.5 volts for operation of boats and cars; (c) While the builder may take liberty with the power harness for the airborne unit, the arrangement shown in Figure 1 is strongly recommended. The switch hook-up should also be used for the transmitter.

A double pole, double throw switch is used to permit easy addition of an external charger. If a charger is to be used, the charging plug or jack should be connected to the back or "OFF" contacts of the switch as indicated. Plus from the charger must go to plus on the batteries and minus to minus; (e) The transmitter will provide quite satisfactory operation from a 9 Volt dry battery such as the Eveready D-6 or Mallory 1603, but don't substitute anything of smaller capacity. This size battery will provide about eighteen hours continuous operation. (f) However, in my opinion, the most satisfactory arrangement is to use a 450 mah, 9.6 Volt nickel cadmium pack for the transmitter. (g) Suitable external chargers are available from Ace R/C, Royal Electronics, and many electronic stores but be sure they provide the proper charge rate for the cells selected for the system, i.e., 10% of the milliampere hour rating. (h) The transmitter may be operated on just seven nickel cadmium cells (8.4 Volts) for car and boat operation. (i) Alternatively, if the modeler finds it necessary, in order to fly in a high interference area, the transmitter may be operated from 10 nickel cadmium cells or eight pencells (alkaline) for 12 volts. However, heat sinks should be added to Q6 and Q7 in the transmitter RF section.

Assuming, at this point, that the transmitter, receiver, decoder, and servos have been constructed and the batteries selected, the following procedure is used to integrate the system. (a) Tune the transmitter in accordance with the transmitter instructions. If a scope is available, set the control pulse widths to precisely 1.5 ms. If not, set the resistance of the control pots at 2500 ohms using an ohmmeter for a close approximation. (b) Connect the receiver and decoder and tune the receiver as described in the instructions with the airborne pack connected to the decoder, but no servos. If a plastic case is used for the receiver, no further tuning is needed. (c) If an oscilloscope is available, check the waveforms throughout in accordance with the scope traces provided with this article. (d) The servo potentiometers should have been set up in accordance with the servo instructions i.e., use an ohmmeter to set the resistance at the terminals to which the short blue wires connect, to 2500 ohms with servo output centered and blue wires unconnected. (e) If the transmitter pulse widths were set accurately with an oscilloscope, ignore the preceding two steps and, instead, set the servos to exact center by inserting a small jeweler's screwdriver in the output shaft and adjusting until centering is correct. (f) Check for smooth, linear travel in both directions.

Having completed the preceding integration, the system is ready for installation. If a glider or power plane is to be flown, a full range check with transmitter antenna extended should be made. Have a helper walk out with the transmitter with the antenna held upright while slowly and steadily moving one control back and forth. Caution him not to move the other controls as it is desirable to use their steadiness as an indication of solid operation. Hold the model at head level and check operation to a range of around 500 feet. Solid operation to this point is an indication of solid operation to an air distance several times greater.

In Case Of Difficulty

In case of difficulty, the procedure for this or any system is as follows: (a) Always check battery voltages first thing. (b) Localize the problem; determine if the transmitter is radiating and the pulse train is present. An audio monitor or an FM receiver may be used for this. The audio hum may be heard on an FM set at around 108 MHz. When the control stick is moved in either direction, the "buzz" should change tone. (c) If, say, one servo is dead but one is good, swap servos. If the servo was bad, it won't work on the "good" channel. If the "good" servo quits, then there is a problem with the transmitter encoder or the decoder. (d) Almost any servo problem will trace to one of two things; a mistake was made in assembly or the IC is bad. (e) If the problem is a servo, recheck the assembly for errors. If none is found, replace the IC. One word of caution; reversal of polarity to the servo or shorting the servo output to ground, no matter how short the time, will ruin the IC. (f) If the problem is not simple battery problems, a servo, or assembly error, then it is desirable to have access to a scope for further troubleshooting although a VTVM may be used to check those voltages shown in the Table 1.

The accompanying sequential scope trace photos pretty well tell the whole story. The shape of the proper signal is evident and the amplitude and period are noted. The number of pulses shown on your scope will depend on the number of transmitter channels. Probable difficulty if the proper waveform is not present is noted. The numbered sequence begins with the transmitter master clock and proceed through the encoder, the modulator, and the RF sections. Proper RF output power can be determined with a field strength meter or by demodulating the RF wave and checking it on a scope or VTVM as described in the transmitter instructions.

Starting with Trace Number 7, the receiver can be checked. One trace which is not shown may be checked on a scope having a sensitivity of .0025 volts/cm, if available, that being the local oscillator output which is a simple sine wave. The shape of the IF waveform at various stages is very much like that of Trace Number 8 but the amplitude is considerably less so don't fret if it can't be seen on a scope with low sensitivity.

Voltages are not provided for the servos because they are ratiometric, meaningless. As indicated earlier, problems with servos are almost certainly one of the two things listed.

For those who do have a scope, problems can be localized to some extent by checking the voltage shown in Table 1 using a VTVM having an input impedance of 10,000 ohms per volt or more. However, localization is much easier using the scope.

Using Parts of the System With Other Sets

This system was purposely created to permit its use with other systems. (a) The receiver-decoder will operate with any transmitter so long as they are on the same frequency and the receiver is tuned to that transmitter. This is one of the major applications envisioned. If this is the case, simply center the servos with the transmitter control and trim centered until the servo output is centered. Do not reset the transmitter used because that will change the centering of servos for the original system. (b) The builder may wish to use an existing, extra servos with the receiver/decoder. Check if the servos require a positive or negative going pulse and make the PC board modification if necessary. The MRC five wire servos need +4.8V supplied to both the red and the green wires. (c) The servos may be used with any positive pulse IC decoder system. The Heathkit 405 series may require a 10K load between signal and ground. (d) The transmitter is rather limited; it will operate a one or two channel receiver system (except for the Kraft KP-2B or the Jerobee receiver which do not use the normal digital concept) and will provide two channels out of decoders designed for more than two channels. The outputs will not necessarily appear at the first two decoder channels and may appear more than once depending on decoder design.

This completes the instructions on the Digital Commander system. We truly hope that those who build the set enjoy success with it. Further, we hope that interest in the material presented here will prompt some of the tinkerers to sit up and generate some ideas for improvement, addition, or just simply new ways of doing things.

TABLE OF VOLTAGE MEASUREMENTS *

Taken with 20,000 Ohms/volt VTVM, DC scale, VTVM ground to OV, all values in volts. If the indicated value is not achieved within about ± 20%, the probable cause is as stated for each measurement, voltage values shown in ( ). Each step presumes voltage checks in preceding steps have been correct. All checks assume that boards affected have been checked for shorts, solder bridges, broken components or leads, and any leads which may touch others.

I. Transmitter - "ON", 9 v Battery

1. Q4 - Base (3.8) Emitter (3.5) Collector (0) Voltage Regulator. Emitter must read (3.4) to (3.8). If not, Z1 or Q4 is bad or incorrectly installed.

2. Q1 - Junction, R2/Q1 (6.8) Junction, R3/Q1 (4.2) Q1 or C1 bad or incorrectly installed.

3. IC-1 Pin 1 (0), 2 (0.2), 3 (2.4), 4 (0), 5 (0.2), 6 (1.8), 7 (0), 8 (3.4), 9 (0), 10 (0), 11 (3.5), 12 (0), 13 (0), 14 (3). NOTE - Voltage at pin 14 should vary ± 0.1 v with full rudder stick movement.

4. IC-2 Pin 1 (0), 2 (0.2), 3 (2.4), 4 (0), 5 (0.2), 6 (0), 7 (1.8), 8 (3.4), 9 (0), 10 (0), 11 (3.5), 12 (0.2), 13 (0), 14 (3). NOTE - Voltage at pin 14 should vary ± 0.1 v with full elevator stick movement.

   Failure to achieve above voltages for IC-1 and IC-2 are probably caused by IC-1 or IC-2 installed improperly or failed; C-3 or C-5 may be bad or improperly in-

stalled; or C-2 or C-4 may be bad. (C-6 will not effect IC-1 or IC-2).

5. IC-3 Pin 1 (0.8), 2 (0), 3 (0.4), 4 (0), 5 (0.8), 6 (0), 7 (0), 8 (0.3), 9 and 10 (0.6 or slightly minus), 11 (0.5), 12 (0.5), 13 (0), 14 (0.8).

   Failure to achieve the readings for IC-3 probably means IC-3 is failed or a leaky expander is involved, in either case, replace IC-3. It is possible but improbable that C7 or R7 might be at fault. The problem of greatest concern is that the reading on pin 3 be relatively close or else Q2 will not be controlled properly.

6. Q2 - Emitter (0), Base 0.2, Collector 6.5
   Q2 bad or incorrectly installed or not being driven properly out of pin 3 of IC-3. Check R8, R9 and R11 for continuity and C-8 for shorting.

7. Q3 Emitter (6.1), Base (6.5), Collector (0)
   Q3 bad or improperly installed. Q2 not functioning properly.Check R11 and R12 for continuity.

8. Q5 Emitter (1.0), Base (1.7), Collector (6.8)
   Q5 bad. Crystal bad. Check continuity of R-15, R-16, and R-17.

9. Q6 and Q7 Emitter (0.2) Base (0.02), Collector (6.8)
   Q6 and Q7 bad or improperly installed. L6 open.

II. Receiver - No Incoming Signal. Nickel Cadmium Power Supply

1. Q1 Emitter (1.5) Base (0.7) Collector (2.4)
   Q1 bad or improperly installed. L1 open. Check continuity and value of R1, R3, and R4.

2. Q2 Emitter (Q.15) Base (0.6) Collector (3.3)
   Q2 bad or improperly installed. Check continuity and resistance of R6, and R7. T1 primary open.

3. Q3 Emitter (0.2) Base (1.0) Collector (3.0)
   Q3 bad or improperly installed. T1 secondary open. Check continuity and value of R9, R10, and R11. Primary of T2 may be open. Can also be upset by shorts in AGC line; R18, R19, C21, and C20.

4. Q4 Emitter (.45) Base (1.0) Collector (4.0)
   Q4 bad or improperly installed. Check continuity and value of R12, R14, R13, and R15. Primary of T3 may be open.

5. Q5 Emitter (0) Base (0.4) Collector (4.1)
   Q5 bad or improperly installed. D1 shorted or open. T3 primary open. Check continuity and value of R16, R17. Recheck AGC line. C22 may be shorted.

6. Q6 Emitter (3.8) Base (4.4) Collector (4.5)
   Q6 bad, check R24 and R25, C24 shorted.

III. Decoder - No Incoming Signal. Nickel Cadmium Power Supply

1. Q7 Emitter (0) Base (.56) Collector (5) Q7 bad or improperly installed. Check value and continuity of R20, R21 and R22. C22 and C23 may be shorted, (these components are on the Receiver board). C1 - C2 shorted, (located on Decoder board).

2. Input to inverter No. 1, Pin 13, IC-1 (1.6)
   IC-1 bad, C1 shorted, R1 open, Q1 defective.

3. Output from inverter No. 1, Pin 1 (into inverter No. 2) (0.05) IC-1 bad. C-1 shorted. Diode shorted.

4. Output from inverter No. 2, Pins 2 and 3 (into inverter No. 3 and to diode) (4.0) IC-1 bad.

5. Output from inverter No. 3, Pin 4 (0.05)
   IC-1 bad. C-1 shorted. Short to + in clock line.

6. Input to inverter No. 4 from diode, Pin 5 (1.5)
   IC-1 bad. Diode bad.

7. Output from inverter No. 4 to No. 5, Pin 6 (0.05)
   IC-1 bad.

8. Output from inverter No. 5, Pin 8 (4.0)
   IC-1 bad. C4 shorted. Short in reset line to J of FF-1.

9. IC-2 Pin 1, 2 (3.8)
   IC-2 bad.

10. IC-2 Pin 9 (1.6)
    IC-2 bad.

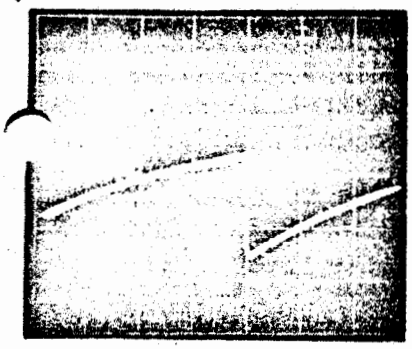
11. IC-2 Pin 3, 4, 5, 6, 10, 11, 12 (0.05)
    IC-2 bad.

12. IC-2, Pin 14 (4.0)
    IC-2 bad. IC-1 bad.

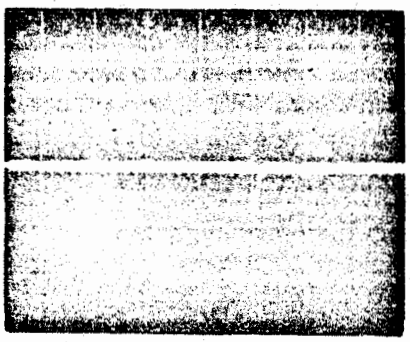
IV. Servo

1. Check supply voltage.
2. Check pot setting (approximately 2500 ohms), and wiper action.
3. Check for shorts to board from wires to motor.
4. Check for p. c. board shorts.
5. Check capacitors, placement, value, and for shorts (remove from board, to check with ohmmeter).
6. Check resistors for placement, value, and continuity.
7. Replace IC-1.

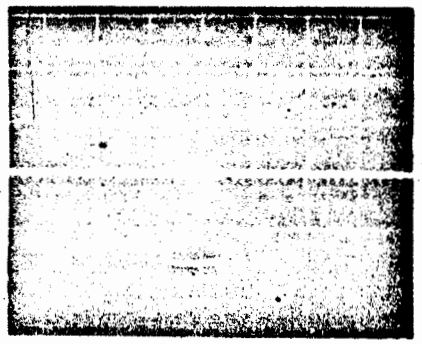
Interference caused by excessive servo motor noise can be eliminated by installing a 1 mf. capacitor across the motor terminals (orange and white wires).



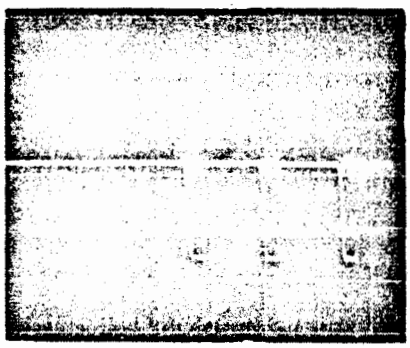
1. Output of Q1, unijunction master clock, 2 v/cm vertical . 2 ms/cm horizontal. Absence means Q1 or C1 bad or improperly installed. Frame rate may be changed by changing value of R3. Increasing gives higher frame rate.



2. The differentiated vertical segment from Q1 at junction of R4 and C2. 0.1 v/cm vertical. 2 ms/cm horizontal. Absence means C2 bad. 1C-1 possibly bad or improperly installed. Similar waveform present at junction of C4/R5 and C8/R6.



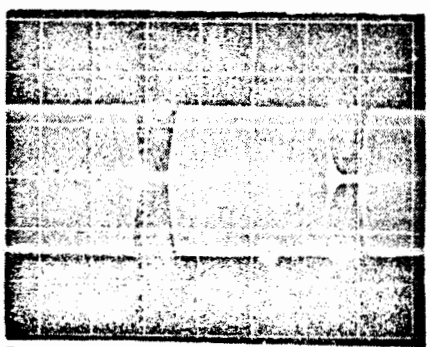
3. Output of encoder one-shots (both look alike) available at pin 14 of 1C-1 and 1C-2. Absence means 1C-1 (or 1C-2) bad, C3 or C5 bad, control pots badly out of proper setting or (for 1C-2) C4 is bad. 2 v/cm vertical. 2 ms/cm horizontal. The width of the pulse should be 1.5 ms, variable from 1.0 to 2.0 ms via control pot.



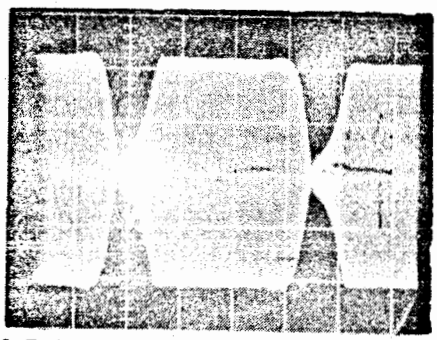
4. Output of expander E3 at junction of R8 and R9. 2 v/cm vertical 0.2 v/cm horizontal. Absence means 1C-3 is bad, provided the three differentiated spikes appear at inputs to E1 and E2, respectively, at pins 6, and 13.

5. Output at collector of Q2, 2N3646. .2 v/cm vertical 1 ms/cm horizontal. Provided that the output from expander E3 was correct, absence of signal means that Q2 is bad or improperly installed. Note the shape of the pulse; it must not be absolutely square but shaped as shown.

6. RF output from Q6/Q7. 0.005 v/cm vertical. 0.02 μ sec/cm horizontal. Visible only on a scope capable of displaying 27 MHz.

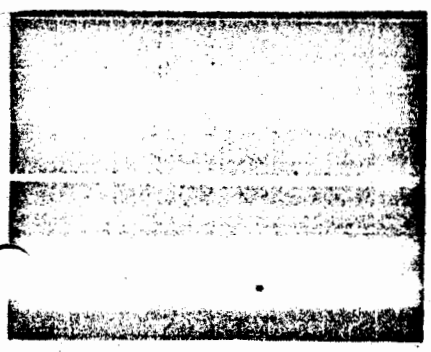


7. Receiver mixer output at Q2 collector. 0.5 v/cm vertical. 0.4 ms/cm horizontal. Lightly shaded area is the 455 KHz envelope. Problems here arise from lack of local oscillator operation via failure of Q1 or XTAL; improper construction of L2 and L3/L4; or improper operation of Q2.

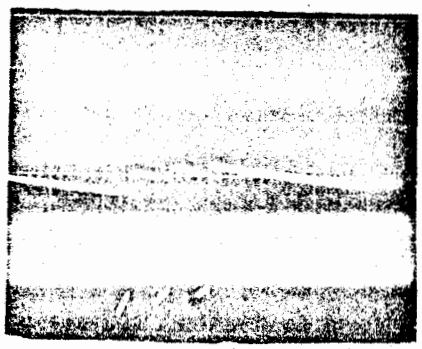


8. Typical IF waveform seen at the output of receiver Q4. 0.5 v/cm vertical. 0.4 ms/cm horizontal. Similar waveforms of varying amplitude and sensitive to transmitter range are present at the output from T1, Q3, and T2. Action may be traced by viewing waveform from the output of each of the preceding components. Exact measurements are possible only with an exactly known input signal level from a signal generator. Signal levels for full AGC limiting condition are listed.

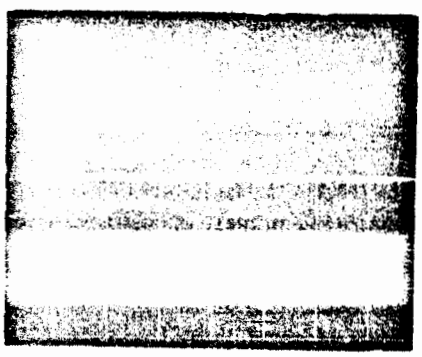
9. Detected output at collector of Q5. 1 v/cm vertical, 2 ms/cm horizontal. With AGC full limiting, i.e., transmitter nearby. The amplitude at this point should change only gradually as transmitter range is changed. Abrupt changes are an indication of AGC instability. Absence of signal at this point means Q5 is bad, provided that IF signal was present through to output of T3.



10. Output at collector of Q1 on the decoder. 2 v/cm vertical, 1 ms/cm horizontal. Shape should be square as shown over full receiver range. Absence of signal means either Q1, C22 or C23 is bad or improperly installed given that the proper signal level was present at output from Q5.

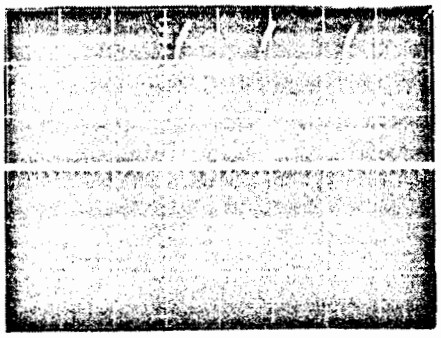


11. Capacitively coupled output to decoder. 2 v/cm vertical. 1 ms/cm horizontal. Absence of signal means C2 is bad or 1st inverter in decoder possibly shorted, given that output from Q1 was correct.



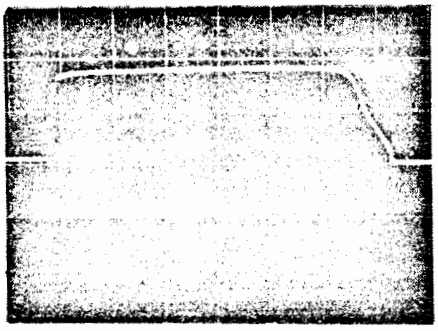
12. Output from first inverter of decoder SN7404 at pin 12. If signal input at pin 13 was correct (i.e., the same as output from C2), absence of signal means decoder 1C-1 (SN7404) is bad or improperly installed. 2 v/cm vertical. .2 ms/cm horizontal.

13. Output from second inverter of decoder 1C-1. .2 v/cm vertical. 1 ms/cm horizontal. Absence of signal, given the proper signal at output from first inverter, means 1C-1 is bad or C3 possibly shorted. Available at pin 2.

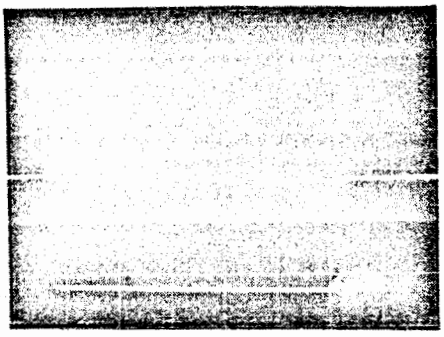


14. Output from third inverter of decoder 1C-1. .2 v/cm vertical. 1 ms/cm horizontal. Absence of signal, given proper input from second inverter, means 1C-1 is bad. Available at pin 4.

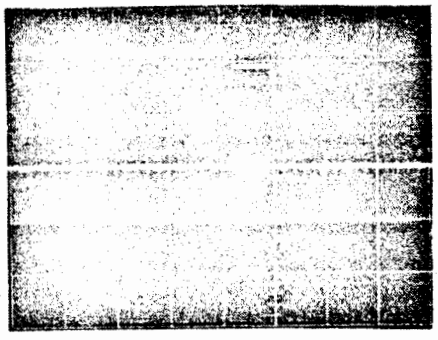
15. Input to fourth inverter of decoder 1C-1. Note the integration of pulses from the second inverter coupled via D1 and integrated by C4. 0.5 v/cm vertical. 1 ms/cm horizontal. Incorrect signal here could be caused by D1 or C4 bad or incorrectly installed (check these first) or 1C-1 is bad. Available at pin 5.



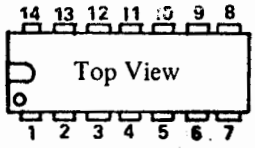
16. Output of fourth inverter of decoder 1C-1. 2 v/cm vertical. 1 ms/cm horizontal. Note that this inverter is controlled by the inverter input which was a sawtooth. If the output has a sawtooth appearance, C4 may be out of tolerance on the low capacitance side. If the input was correct, absence of output can be caused only by a bad 1C-1. Available at pin 6.



17. Output of fifth inverter of decoder 1C-1. This inverter takes the output from the fourth inverter, further squares and inverts it. Absence of signal means 1C-1 is bad. Output from fifth inverter is available at pin 8 of IC-1.



18. Output of IC2 pins 3, 4, 5, 6, 10, 11, 12, 13; if used. 2 v/cm vertical. 2 ms/cm horizontal. The only cause for lack of signal is a bad 1C-2. It is possible for this signal to be degraded by a failure in a servo so it should be checked both with and without a servo plugged in.



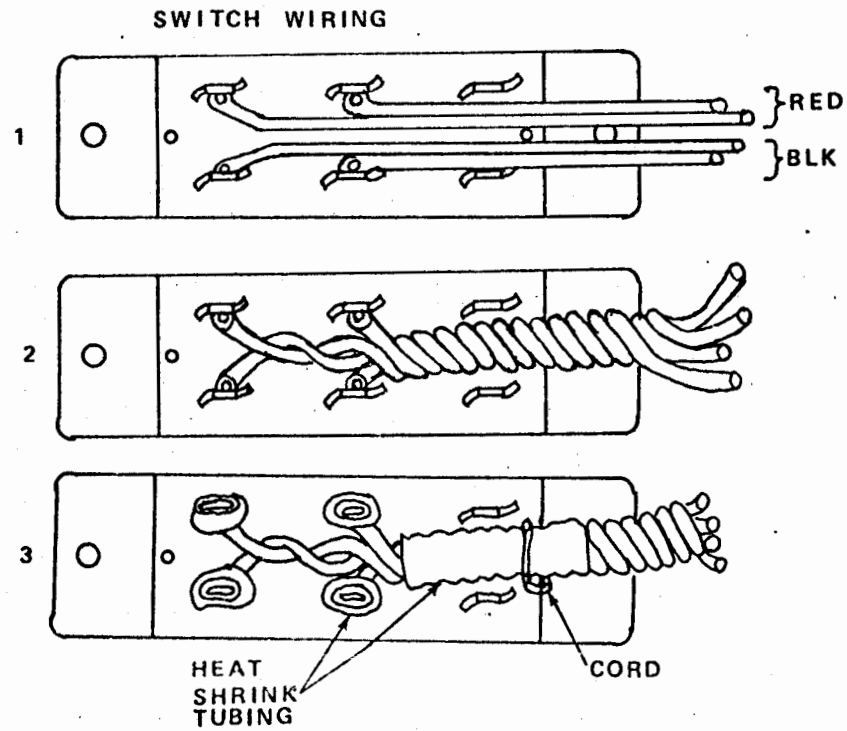


FIGURE 1